App. F. IX-4

1933.

File No. 15-33

Serial Nos. 1-6.

Previous References

Exec 65-32(1-3) Exec Dep 24-33
" 19-28(1-2) Exec 60-32(5+6)
" 44-30(7+8) " 44-30(5+6)
" 8-30(1-2) " 44-30(2+4)
" 5-29(9-10) " 44-30(1,3)
Later References. " 88-29(5+6)
" 88-29(3, 7+8, 4) " 4-29(1-2)
" 88-29(1+2) " 19-28(3+4)
" 5-29(12, 16)
" 5-29(11, 13-15)
" 5-29(5-)
" 5-29(1-4)

See 587-41-1

GENERAL AND REVENUE SECRETARIAT.

Serial Nos. 6

Part B for May HO.

SUBJECT.

Manufacture of Ferro Chrome & Ferro Silicon

Records the proposal, as no action is necessary

WD 0573—GPB—22,500—12-9-89

1262

Serial No.

No. D. 1641

Geol. 15. 33-2

9. 10 33

Dear Mr. Barlow Has

Will you please let me have a note as to the results of the experiments about ferro-silicon & ferrochrome that were recently taken by the Department the results so far obtained & what further action is being taken sometime ago. I should be obliged if you will kindly give your first attention to this as the matter is urgent

Yours very
truly

2 Before any

Please find out if there is any file here that will give us the information required without this reference

3 The file is transmitted
First member

4 9.10.33 - 9/10.

5 Letter may issue for
9/10/33

Dept. No 1262-33
Geol 15-33-1

Final ... No. 2710

TYPING SECTION
10. OCT. 1933
GEN'L & REV. SECT'T

2

To - The Offg: Director of Geology
No. D. 1047 Dt 11.10.33

10.10.33.

10/10

Calls for a full note as to the Government about ferro-chrome & ferro Silicon with the information so far obtained & further action to be taken —

NOTE—Contn. Sheet.

WD 70—GBPM—60,000—13-8-31.

2

fort

1361 1391

File No. 15 of 1933. | General and Revenue Secretariat

From the Govt of Govt
No 7135-204 dated 31/10/33
Sending a note called for in Pt
2 above
Submitted with reqr to paras 1 + 5 above

OFF
FIRST ML
14 OCT. 1933
No. 7879

Pvt KP
4/(10/33) First Member) 7 Sec 14/10

I showed the file and the Secretariat files on this subject

The report received from the Dist Rama Rao unt. 9 15/11/33
is also put up. 16.10.33.

1° Submitted with the following collections

(1) Govt 19-28-2 Zero-charge Experiments in the Central College (1928-29)
(2) Govt 5-29-10 " (1929-30)
(3) Govt 8-30-2 " (1930-31)
(4) Govt 44-30-8 Experiments at Bhadrachalam (1931-32)
(5) Govt 65-32-3 Experiments at Sivasamudram (1932-33)

Other available collections are also put up for reference

(1) Govt 19-28 (3-4)
(2) Govt 4-29 (1-2)
(3) Govt 5-29 (1-4)
(4) Govt (5-29 (3-7)
(5) Govt 5-29 (11,13-15)
(6) Govt 5-29 (12,16)
(7) Govt 88-29 (1-2)
(8) Govt 88-29 (3,3a,4)
(9) Govt 88-29 (5-6)
(10) Govt 44-30 (2-4)
(11) Govt 44-30 (1,3)
(12) Govt 44-30 (3-6)
(13) Govt 65-32 (5-6)

Pvt KP
17/(10/33) First Member) 11 Sec 17/10/33

OFFICE OF THE
17 OCT. 1933
2952

Serial No.

12

These papers about the matters regarding the work done at Bhadravati & after was decided to discontinue it at the end of June 1932 — now the ~~xxx~~ papers re instructions issued in March 33 for starting experiments in ferro-silicon productions. I should like to see these

Ku 18/10/33

13 Cash 14 $10 19.10.33. 19/10.

15

Submitted

The papers relating to the manufacture of ferro-silicon are put up.

As no ~~information~~ details is available as to the nature & result of the work done at Bhadravati, a draft calling for the same is put up for approval or otherwise.

~~draft~~

Kind reg. is marked to Flag F in which ~~explaining~~ reasons are given for stopping the experiments at Bhadravati

Cal 21/10

16 Issue $10 21/10/33.

No. D 1753 Dy 21.10.33.

The Director of Geology —

Enquiries as to why the experiments at Bhadravathi were discontinued at the end of July 1932.

3680 Geol 65-32-4 Flag K.

K

Ker Secy — 19.10.33.

TYPIST SECTION 21 OCT 1933 3-45 P.M. SECT

NOTE—Contn. Sheet.

6

From the Mine Officer Geol
No 7135-212 dated 26/10/33

Submits a further note on the investigations carried on at Bhadravati for the production of ferro-alloys

17) Noted with reference to para 12 above.

~~and 15 above~~

Gnl 18) Re Instructions issued in March 1933
25/10/33 for starting experiments on Ferro-Silicon productions - attention is invited to letter no 149 dated 14.3.1933 to Mr C.M. Cariappa Mysore

KP
26/10/33 - Dev: See 1)

C/10
26/10.

~~First Member~~

~~Dated~~
~~26.10.33~~

19) It is seen that Ferro chrome experiments were given up at Sivasamudram about April 1933 and attention diverted entirely to the production of Ferro Silicon. The constituents of the Ferro Chrome alloy produced were Cr. % 55.97 & Fe % 37.82, the remaining % 6.21 being carbon whereas the marketable alloy should contain a very much less percentage of carbon.

OFFICE OF THE FIRST MEMBER OF COUNCIL 26 OCT. 1933 No. 3151

First Member.

C/10
26/10

Serial No.

20) Please let me have copies of
(1) Govt Dir's letter of 26 31 (in Govt. file 44-30) with its enclosures
(2) the enclosures to Govt Dir's letter No 7135-112 of 24-10-33
(3) the enclosure to the Govt Dir's letter No 7135-208 of 16-10-33

Q-3.

E

26 The Typing section for favour of immediate compliance

2-11-33. 2/11

TYPING SECTION
2 NOV. 1933
4-45 P.M.
GENL. & REV SECT.

3 Nov 33 4 x 2 copies

21) Submitted with copies of the above letter.
4/11/33 Dev: Sec'y) 4/11

First Member.

Ⓓ No enclosures were sent to Prof Bhavihar today with a Dy.

22) Ⓢ P.H. Take round to Prof Venkatachalam. 6/11

7/11/33

3-5-32

Subs till 1.12.33
Dep
Ad
10/11/33

7-11-33 8/11

DEVELOPMENT

NOTE—Contn. Sheet.

Geol. 15-33-9

INDIAN INSTITUTE OF SCIENCE,

BANGALORE, INDIA.

29350

POSTAL ADDRESS:
HEBBAL, BANGALORE.
ALL LETTERS, PACKAGES, &c., SHOULD BE ADDRESSED TO THE DIRECTOR.

Bk/5165

TELEGRAMS:
"SCIENCE", BANGALORE.
CODE: A.B.C. 5TH EDITION.

3rd February 1934.

Dear Diwan Bahadur Matthan,

Professor Venkatesachar showed me your letter of the 7th November and the accompanying notes and reports regarding the experiments on the production of ferro-chrome and ferro-silicon. On enquiry, I learn that Mr. Rewati Raman who was working on the subject at the Institute under Professor Mowdawalla left the Institute about a year ago and that nothing has since been done on the subject.

I am very anxious to give you all possible help in this matter, but have been in some difficulty owing to the fact that this problem requires the co-operation of several different departments of the Institute and that nobody at present is available at the Institute with special knowledge of metallurgy. It is not clear from your letter whether you desire the Institute to take up experimental work on the subject. If that be your desire, then we could proceed to discuss ways and means for doing so.

Yours sincerely,

C. V. Raman

Rajamantrapravīna
Diwan Bahadur K. Matthan, B.A.,
Member of Council,
Public Offices, Bangalore.

Serial No.	

Ferro-cement Experiments

Geol

File No. 15 of 1933.

General and Revenue Secretariat

Serial No.

were ordered to be discontinued (vide
f o no D 3066-S / Geol 15-33-8 dated
23/12/33

VdHP
7/2/34 Dev: Sec'y)

CMO 8/2.

First Member.

CMO 9/2
CMR
9.2.34

* Issued vide 2265 - removed & put-on with the file 3342

OFFICE OF THE FIRST [illegible] 1934 No. 618

24) Discussed with Prof. Venkatesachar his view that this Experiment might be conducted in the Dept of Science - But in view of impending changes in the Elec Dept of the Instt, the matter may be with held upto April Please resubmit about 10th April

Govt B dtd 16 April 1934

REVENUE SECTION 2

DEVELOPMENT BRANCH

CMR
16/2/34
CMR
16.2.34. CMO 16/2

25) The file may be resubmitted to the Member on his return to Bangalore. If he approves he should like to discuss the question with him whenever convenient to him

MW 28.6.34 CMO 28/6

26) Resubmitted as directed above
CMO CB
9/5/34

First Member)

CMO 9.5.34

MAY 1934 6834

27) Govt SD. to [illegible] action in accordance with the [illegible] 1931 [illegible]

RR 8/7/34

Serial No.

28) No action seems to be necessary at this stage of the proposals. If agreed the papers will be filed

29) For orders

Dev: Secy

30) forwarded with compliments to the Director of Geology, inviting his opinion as to the nature of means which it is necessary to conduct any further experiments, and if so what steps he would himself propose to take to carry them out and what arrangements should be made for such experiments with the Department of Science

Director

U.O.No. G. 723 dated 19-9-1939.

31) Mysore chrome ores contain too high a proportion of iron for profitably manufacturing 70% ferro-chrome, and the investigations already conducted during 1930-32 were not thoroughly successful. However, it is desirable to conduct some further investigation on the possibility of manufacturing lower grades of ferro-chrome. How best to arrange for this is engaging my attention. It would be

p.t.o.

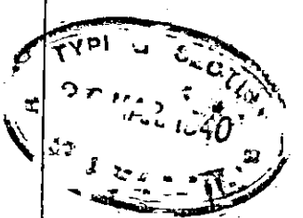
NOTE—Contn. Sheet.

WD 0156—GPB—7,500—5-4-31

be possible for the Chemists of this Department to conduct further investigations provided they get all the required facilities. A detailed note on this question will be sent later, after studying all conditions.

P.R. Ramaiya
DIRECTOR,
Mysore Geological Department.

Ar.19/9



32) may be awaited

20/9

33) Reminder is put up for approval.
19/3/40

AF 5086 d. 25.3.40. To, the Dir. of Geol Reminder R
Letter No. G 1891 d. 6.4.40 from the Dir of Geol. States that it has not been possible to make any arrangements to conduct the experiments and that these experiments can be conducted with advantage at Bhadravati by the Mysore Iron & Steel Works.

"Submitted with reference to para 30. above. It is for orders whether the Secy. Board of Management Mysore Iron & Steel Works may be consulted unofficially, if it is possible to conduct the experiments at Bhadravati as suggested by the Dir. of Geol. and if so, to

Manufacture of lower grades of ferro-chrome

General and Revenue Secretariat. | File No. 15 of 1933 | App. F. III-2

Serial No.

suggest the ways and means for doing so

Km 11/4/40 12/4 34 A may be done

Dev. Secy 12/4/40

35 yes C 17/4

18/4

No. 273-7435-C0 dt. 18-4-1940

36 Forwarded with compliments un-officially to the Secretary Board of Management Mysore Iron and Steel Works for favour of remarks.

Hemachandra Rao

for Development Secretary

18/4/40

Km 18/4/40

B.636 8/5/40.

37) Returned with compliments.

Proposals have been submitted to Govt separately for sanction to the installation of Ferro-Alloy furnaces, and sanction is awaited. As soon as these are installed it is proposed to manufacture ferro-silicon regularly, and ferro-chrome off and on, as an experimental measure, till a marketable product is made.

NOTE-Contn. Sheet.

11 4

File No. of 19 | General and Revenue Secretariat.

Serial No.

GEOY. DEV DEPT. 9. MAY 19 40 GOVT OF MYSORE

GEN. & REV. SECTT. - 9 MAY 1940 AGRI. & FOREST BRANCH.

(50) The Mysore chrome ore has relatively a higher iron content, so that it is not possible to make a high grade ferro-chrome in a straight process. However there are some patented processes by which the iron could be eliminated and a high grade product made.

Bhadravati
8.5.40

Srivastava
Secretary to the Board of Management, MIS&W

RWS

(51) No. action seems to be necessary now. The papers may perhaps be filed.

Kmn
21/5/40

MAY 16 1940
No M-823

GEN. & REV. SECTT.
22 MAY 1940
AGRI. & FOREST BRANCH.

4694 A
399
12

Extract from letter dated 24.4.1940 from Dr. E. P. Metcalfe, Little Hendra, Shire Lane, Chorley Wood, to the Dewan.

DEVELOPMENT BRANCH

---

x x

(10) Another point I want to refer to concerns the Mysore Chromium. I mentioned this in a former letter. You may remember that we began some experiments in the smelting of ferro-chrome; and we got as far as making samples of crude alloy. The next stage would have been the purification by removing carbon; and I had a plan for this. The commercial process is a guarded secret, I believe. It seems to me that under present conditions it might be possible to persuade the Ministry of Supply to facilitate the preparation of pure ferro-chrome in Mysore, since this would save tonnage in transport. Thus you might be able now to get this new technical industry started much more easily than formerly, because the necessary information and plant might now perhaps be available. This industry could probably be worked in conjunction with Bhadravati and might become an important and permanent business.

x x x

DEWAN'S OFFICE
12 MAY 1940
NO M 2399

"COPY"

Edalorle
12/5/40

(11) Submitted to the Hon'ble Member for kind consideration.

By Order,

Edalorle
12/5/40

Private Secretary to the Dewan

(12) A copy of this may be sent to the observer at M. G. S. W. and another kept on the file

16/5/40

Dewan)

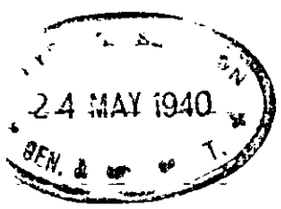
Serial No.

(10 1 5 (16 78

13

(13) Draft subd. as per orders of the I Member in para 38 above. After wine the papers may perhaps be filed, as no action seems necessary. - WH Issue 23/5/40.

kcm 23/5 22/5/40.



Ps kcm 28/5

AF 6585 d. 27.5.40. To the chairman Mysore Iron & Steel Works, Bhadravati Copy of extract from the letter of Dr. E.P. Metcalfe issued

Please send me the file containing Dr. Metcalfe's letter re. Investment in the proposals for the extension of the Iron Works.

Ce 27/5

IW 40-39 Future Developments in Ironworks with Secy

D 4477 — 25/5

Subd

The file is put up.
kcm 27/5/40. Copy of Dr. M's letter given to me. Ce 27/5.

HC 28/5

NOTE—Contn. Sheet.

Files 65-32+34

MR. C. M. CARIAPA.
CHIEF ELECTRICAL ENGINEER.

OFFICE OF THE CHIEF ELECTRICAL ENGINEER
TO THE GOVT. OF MYSORE.
Camp, Sivasamudram

D. O. No. 2105

Bangalore 17th March 1933

3630 (S. India).

ELECTRICAL DEPARTMENT GOVT OF MYSORE
22 MAR 1933
No. M 1957

Dear Sir,

I beg to acknowledge with thanks your D.O.No.149 dated 14th March 1933 together with the pamphlet on "SODERBERG ELECTRODES" enclosed therewith, regarding investigations to be made for the manufacture of ferro-silicon.

I have handed over the pamphlet to Dr.Ram Prasad and instructed him to arrange for carrying on the experiments and I shall send his report in due course. I have also instructed him to send a requisition to the Geological Department for the necessary raw materials and so forth.

Yours sincerely,

C. M. Cariapa
17.3.33

CMC-PRN

To
Rajakaryaprasaktha,
Dewan Bahadur M.N.Krishna Rao, Esq.,
First Member of Council,
Bangalore.

DEVELOPMENT

No. 149

Enc. one.

14th March /33.

Camp Bhadravati,

Dear Sir,

You have been good enough, at my suggestion, to resume experiments at Sivasamudram in ferro-chrome. I understand from the Director of Geology that he has sent there all the connected apparatus and also some quantity of chromite. I dare say the work has been started and hope to hear, in due course, the result of further experiments made there.

It has been suggested to me that we might conduct some investigations in making ferro-silicon also. I understand that the process of making this alloy is almost the same as that of making ferro-chrome. I am also told that the same furnace and transformers will equally do for making ferro-silicon. This alloy is even more important than ferro-chrome as there is an appreciable demand for it in India. The Tata Iron and Steel Company consume annually about 3,000 tons of this material for making steel. They are now buying this article from Europe or America, and paying, I believe, quite a stiff price for it. If we can make this material, satisfying the specifications of the Tatas, we can come to an agreement with them for its sale. I learn that the manufacture of this alloy is not likely to be more difficult than making ferro-chrome; on the other hand, I understand that it is likely to prove an easier proposition. If we succeed in making this alloy, we might feel almost sure of starting an industry which will consume a fairly large block of electric power. I would, therefore, request you to have a few experiments made at Sivasamudram in making this alloy as well.

The

The only raw materials required for it are, I am told, steel turnings, pure quartz, and, coke or charcoal. The Porcelain Factory at Bangalore is using quartz which, I believe, has been found to contain 99.9 per cent. of silica, and this quartz will, I understand, be quite ideal for making ferro-silicon. Dr. Ram Prasad could obtain a supply of this material crushed to any mesh. As for steel turnings, there should be plenty of them in your Workshop at Sivasamudram.

A copy of a pamphlet on "SODERBERG ELECTRODES" in which some operating data for the manufacture of ferro-silicon are given, is herewith sent and it may be passed on to Dr. Ram Prasad. After he is done with it, he may return it to Mr. D. V. Krishna Rao, an officer on the staff of the Mysore Iron Works at Bhadravati.

Yours sincerely,

C. M. Cariapa, Esq.,
Chief Electrical Engineer,
BANGALORE.

14

Letter No.4001-202 dated the 26th June 1931 from the Offg. Director of Geology in Mysore, Bangalore, to the Secretary to Government, Development Department, Bangalore.

I have the honour to submit herewith for the favourable consideration of Government the following observations and recommendations of the Ferro-chrome Committee which met on the 25th June 1931, when all the members were present.

A brief report on the work done in connection with Ferro-chrome experiments during the years 1929-30-31, as drawn up by the Ferro-chrome Assistant, Mr.Y.N. Sreekanta Sastry, B.Sc., and approved by the Committee, is submitted herewith for the information of Government.

"The Committee are of opinion that the experiments which have been carried out yield definite information regarding the working of the process of smelting the chromite ore; Ferro-chrome has been prepared with carbon content up to 8 per cent; by a second process the carbon content has been reduced to 4 per cent, and in certain cases down to under 3 per cent. The experiments in refining or reducing the amount of carbon in the alloy have also given some information, though not yet sufficiently definite.

The Committee strongly recommend (i) that some six more experiments should be conducted in the 3 phase Heroult Furnace of the Mysore Iron Works at Bhadravati so that a larger charge of about 4 cwts. might be dealt with at a time. This would help to obtain some further useful information, specially as regards the cost of the smelting process, worked on a fairly large scale.

(ii) That work on the decarbourising process

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process should be continued - which would require an Induction furnace at a cost of about Rs.25,000/- to Rs.30,000/- for a capacity of 5 cwts. This figure is subject to revision when details of cost are obtained from the sellers.

(iii) That further experiments may be carried on in the small Induction furnace in the Electrical Laboratory of the Indian Institute of Science, Bangalore, with the co-operation of the Professor of Electrical Engineering of the Institute, with an idea to study further the chemistry of the decarburising process.

In order to carry on these experiments, it is necessary that the services of the Ferro-chrome Assistant Mr.K.N.Srikantasastry, should be continued for another year. The Committee approve of the satisfactory work done so far by Mr. Srikantasastry and they strongly recommend that he should be continued in service for another year from 1st July 1931 on a salary of Rs.125/- per month."

In submitting the above recommendations of the Ferro-chrome committee, I beg to state that further experiments should be conducted on a larger scale, preferably at Bhadravati where an electric furnace of the Heroult type is available. If the necessary electric power could be had there, such experiments on a large scale would enable us to estimate the cost of producing the alloy on an industrial basis.

There is a very fair chance of our being able to make Ferro-chrome of good quality at competitive prices. Such product could be disposed of in two ways, either as an alloy sold mostly in the foreign market or used locally as a necessary ingredient for the manufact of chrome steel if such business is actually undertaken.

As the cost of production is an important factor so far as sale in the foreign market is concerned, some definite information is necessary on this point from experiments on a larger scale.

The best method of refining the alloy, that is, the reduction of its carbon content, so far known is by means of induction furnace which would cost about Rs.25,000/- to Rs.30,000/-. Such a refining furnace would give us the cost of the final pure product prepared on a large scale. Whether this amount of money could be spent at this time of financial stress is a matter which is to be decided by Government. A counter-balancing consideration is the fact that the cost of appliances would probably be low n w. But some experiments on this refining process might be conducted in the small furnace available at the Indian Institute of Science; this however would not give us any definite information regarding the cost of production of refined alloy on a large scale.

Taking all these points into consideration, I agree with the recommendations of the Committee and I strongly support the proposal that the services of Mr.K.N. Sreekantasastry should be continued for another year to conduct these experiments from 1st July 1931 on a salary of Rs.125/- per mensem.

If the Mysore Iron Works are agreeable to give us all facilities to conduct these experiments in their Heroult furnace, the charges incurred therefore as well as the pay of the Ferro chrome Assistant, Mr. Sastry, will be met out of the Mineral Survey and Prospecting Work grant of this Department during the year 1931-32.

Early orders of Government are solicited.

"Copy."

vvk.2.

FERRO-CHROME EXPERIMENTS.

A BRIEF REPORT OF WORK DONE IN THE YEARS 1929-30-31.

Attempts were made to produce ferro-chrome from chromite ore and investigate into the possibility of its manufacture.

*****

CHEMICAL THEORY.

*****

Pure chromite has the composition represented by the formula FeO. $Cr._2O_3$. But in the Ore it is usually associated with alumina, magnesia, silica, calcium oxide and sometimes nickel oxide in varying proportions. To get ferro-chrome the ore is therefore reduced with a suitable reducing agent, preferably, carbon, which is economically favourable in a State like Mysore where the forest resources can supply wood charcoal in abundance. In this process of reduction of iron and chromium oxides to metallic condition, impurities like alumina, magnesia and silica run out as slag.

The reduction of chromite with carbon takes plac according to the reaction:-

$$FeO.Cr._2O_3 + 4\ C = Fe.2\ Cr + 4\ CO.$$

The reduction of chromic acid starts at 1185°C. The reaction is exothermic yielding 2430 calories of heat for every gram of carbon oxidised to carbon monoxide. The chemical heat further assists the reaction. The entire reduction is performed by solid carbon and not by carbon monoxide.

We do not possess any aid to measure high temperature as that of electric arc, and therefore are unable to study the varying effects of temperature on the composition as well as the constitution of the alloy produced.

EQUIPMENT.

The high temperature needed for the reaction was obtained in the electric arc furnace. The furnace is open-to

type being built, all round of Austrian magnesite bricks 9" by 4½" by 3" supported at the bottom on a mild steel plate ¼" thick. The bricks were in the initial days cemented by "Sternson Monolith." Experiments were also tried with success to use the more common materials locally available to form a good refractory cement. The furnace is therefore compelled to be square in section and not cylinderial as is the general practice where cylinderial graphite electrodes are used.

The low voltage needed for the arc was tapped, to begin with, on the secondary winding of a 15 kVA. 220V/110-55-30-15 V single phase transformer, in the primary circuit of which was introduced a 6 kVA. 88-58.7-29.3V/68.2 A. reactor to steady the arc as also to arrest the line surges. A saltwater rheostat was inserted in series with the furnace to control the load current.

EXPERIMENTAL DETAILS.

At commencement the furnace was worked on the model of a Siemen's vertical arc furnace with a single vertical graphite electrode 2" in diameter. The different voltages, viz., 110 and 55 were tried to determine the most favourable conditions under the difficulties encountered during the fusion of ore. Three experiments were conducted by running it also as a single phase series furnace. To eliminate the serious difficulty, viz., the hardening of the slag and the consequent extinction of the arc at the commencement of an experiment devices were provided to shield the arc from the products of reaction. This method proved quite successful and highly encouraging.

Meanwhile, attempts were also made on the lines of the French practice to try resistance furnaces wherein special features like possibility of obtaining

obtaining purer samples of product, uninterrupted working etc., are claimed. The simplest type of furnace that could be constructed from materials within reach was made by using graphite slices arranged on contact resistance principle for the resistance element. It was not workable as high temperatures could not be developed under the electrical limitations of our plant, with all efforts to improve the resistance.

MUFFLE FURNACE.

Attempts were also made to try electric muffles and, accordingly, some experiments were conducted in the 11 kW silit-resistor muffle furnace manufactured by R.A.Catterson Smith, Chelsea, London. In the course of the first three experiments we could discover that the thermo-electric Bowen-Pyrometer attached to the furnace was not reading accurate. As conducting a high temperature a reaction without knowledge of the working conditions was not considered safe for the muffle, we equipped ourselves with an optical pyrometer which clearly showed that even after continuous run for 8 hours the required temperature was not reached.

SINGLE PHASE ARC FURNACE.

Our experiments were therefore carried mainly in the arc furnace. When impurities in the Ore like alumina, silica and magnesia are slagged in the process of reducing the ore, iron and chromium also have got the tendency of running into the slag. In the early stages such slagging of chromium was so great that it seriously affected the composition of the alloy and the value of the yield. Considerable improvement was effected in succeeding experiments as

as a result of which almost the theoretical yield was obtained and the slagging of chromium greatly diminished. The most favourable condition could not, however, be obtained as, with our small plant, control over the different conditions was found difficult. Moreover, a study of the dynamic rate of reaction of the substances is also warranted. The different grades of ore were successfully tried and in all cases samples fairly homogeneous in constitution were obtained. As experiments in the single phase arc furnace looked quite promising it was resolved to next try the three phase furnace hich is more usually the practice, chiefly on account of the facility of power transmission and supply.

Three experiments were performed in the resistance furnace, four in the muffle and twenty-eight in the single phase arc furnace.

The total amount of ore used up for fusion was 150 lbs. with 60 lbs of charcoal, 25 lbs. of lime, 1 lb. of sodium silicate and ½ lb.of alundum.

The quantity of ore powder used to line the surface weighed about 50 lbs.

HOSKIN'S FURNACE.

An experiment was tried by Mr. Sampat Iyengar in December 1929 in the Hoskin's furnace at Bhadravati. The result was, however, not satisfactory as in the middle of the run the roof that was constructed of silica bricks was reported to have melted away.

DECARBONISATION.

When chromite is heated with carbon,ferro-chrome is not the only solid product formed; the double carbid

4

carbide of iron and chromium is formed according to the reaction:---

$$9\ (\ FeO.\ Cr_2O_3\ ) + 50C = 2\ (Fe_3C.3\ Cr_3C_2) + 3\ Fe + 36\ CO$$

This reaction is based on the assumption that all the (Fe.2 Cr) formed enters into reaction with carbon. It has been experimentally found that under varying conditions of temperature etc., double carbides of different compositions are more likely in contact with Fe and Cr, because of our production of samples varying from 6 to 10% in carbon. The optimum value is, however, to be worked out by further investigations.

Attempts were made to decarbonise the ferro-chrome by melting it in contact with chromite itself according to the reaction:-

$$2\left[2\ (Fe_3C.3Cr_3C_2) + 3\ Fe\right] + 7\ (FeO.Cr_2O_3) = 25\ (Fe.2Cr) + 28\ CO$$

Attempts were threfore made in the single phase furnace to melt the alloy; they were, however, futile.

The attention was later directed towards induction furnace. Accordingly, experiments were first conducted under varied conditions in the 8 kW 10000 cycles experimental coreless induction furnace installed in the department of Electrical Technology at the Indian Institute of Science, Bangalore, under the kind permission of Prof.J.K. Catterson Smith and the help of his Assistants. In consequence of internal short circuit in the furnace windings, a steady state of temperature was attained far below the melting point of the metal. Experiments with the induction furnace were therefore temporarily suspended awaiting the remedy of faults.

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The induction furnace is, in modern practice, universally regarded as the easiest and most efficient method of metallurgical refining; but in order to avoid two different kinds of plants - involving two separate investments - it was decided to try decarbonisation in the arc furnace. But, on the other hand, it is clear that in carbon(graphite) arc the production of a totally carbon-free alloy is impossible so long as it is in direct contact with the arc. A low-carbon alloy may, however, be possibly made as the electrode carbon, manufactured under high compression, is not likely to dissolve appreciably in the metal.

With a view to attempt total decarbonisation, methods involving indirect heating due to radiation and conduction were, therefore, first employed. In this method, the temperature developed was insufficient to meet the requirement - even with all precautions for heat conservation by proper thermal insulation:- it was however thought desirable to make use of the property that ores are electrically better conductors when heated to a high temperature. Conductivity measurements were, therefore, made on chromite at sufficiently high temperatures. As the resistivity was very high being of the order of meg-ohms, chromite could not be used as contemplated. The idea of production of carbon-free ferro-chrome in the arc was given up.

THREE PHASE ARC FURNACE.

Meanwhile, as the equipment for the three phase work arrived, the old installation was dismantled, fresh plant installed, a furnace of bigger capacity built with a non-conducting hearth and the necessary connections established. Experiments were conducted in this furnace both

both on reduction of the ore and decarbonisation of the alloy, ferro-chrome.

Attempts were made to tap the metal out of the furnace after reduction from the ore. The difficulty in keeping the slag quite molten has been the most serious problem on a small scale work like this. Attempts to render the slag fluid by addition of fluxing agents like fluorspar had a ruinous effect on the furnace lining apart from its effect on the constitution of alloy, thus causing the metal to sink down to the level of the bricks and making only the slag flow out. The alloy became too spongy with numerous blow holes when allowed to cool in the furnace.

In the process of decarbonisation, many troubles were encountered in first getting the metal molten on the small scale. After various alterations in several directions, viz., changes in the interior design of furnace crucible, alignment of electrodes and the grading and feeding of charge, the problem of getting the metal easily molten was solved; the metal too was tapped out of the furnace. Decarbonisation has been carried to the possible extent and the several causes like the centrifugal phenomena (actually observed in the experiments) that might affect the degree of decarbonisation are to be studied.

INDUCTION FURNACE.

In the meanwhile the high frequency induction furnace at the Indian Institute of Science, Bangalore, has been brought into working condition. Work carried therein has shown that, probably on account of the divergence of the value of magnetic permeability of ferro-chrome from that of steel or soft iron and also on account of the different melting temperatures of the

the products, proper homogeneous melting is difficult. Addition by fluxing agents had a most serious effect on the lining employed, thus rendering the decarbonised metal impure in contact with the graphitic carbon tube that was used to tighten the magnetic coupling. Several modifications are being made not only to improve both the mecnanical and electrical design, but to substitute several other refractories and study their effects.

In the three-phase furnace, 24 experiments were conducted on the reduction of chromite ore. On the total 300 lbs of ore were used with 135 lbs. of charcoal, 12 lbs of coke and ½ lb. fluorspar. The total production of ferro-chrome is about 85 lbs. 28 experiments were conducted on the decarbonisation of ferrochrome in the arc furnace of which eleven ended in failures. The metal showed a tendency of short-circuiting the arc. The total quantity of chromite ore power used i 45 lbs., fluorspar being about 2 lbs. It has been found easy to secure a 4 per cent carbon alloy in the arc, though in two experiments about 2½% carbon alloy is got.

ENERGY CONSUMPTION.

In the earliest stages of our experiments the energy consumed exceeded 30 units per pound of high carbon alloy produced. By invigorating the process and minimising the slagging of chromium and improving the yield, it is possible to produce high carbon ferrochrome at 10 units of electric energy per pound even in the small equipment we have. The decarbonisation too has been found to require electrical energy at 10 units per lb. of low carbon alloy produced.

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EXPERIMENTS AT BHADRAVATI.

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With a view to compare our figures for electrical energy with the ones that could be expected on a comparatively large scale, two experiments were conducted during last September on the production of high carbon ferro-chrome from chromite ore in the 270 k V A., Heroult ½ ton steel furnace at Bhadravati. As the ore and charcoal are much lighter in density than steel scrap, they constitute a larger bulk than iron. Therefore, the furnace could take in about 3 cwts of the ore. Work even on this size, clearly showed that the attendant troubles too frequent and quite common on a small scale work, were totally absent on the larger scale and still less on a manufacturing scale. The energy consumption to get a 6 per cent carbon ferro-chrome was as low as 4.8 units per pound. It is not unreasonable to expect a far lower value on a manufacturing scale and continuous operation if we compare the figure given by R.M.Keeney, who, from date collected from Europe and the United States has, on the basis of a total production of six tons of ferro-chrome per day from two 750 kW. furnaces in continuous operation, arrived at less than 3 units per pound of ferro-chrome containing 5 per cent carbon.

As originally the Heroult furnace at Bhadravati was built of magnesite bricks only up to the slag line, above which were used silica bricks, the roof of the furnace was badly damaged on account of the additional chemical heat produced on the de-oxidation of the ore. Work in that furnace was therefore unfortunately stopped. There is no doubt in declaring that better results than now, on decarburisation work, could have been got at.

if that Heroult furnace were made available for our further work.

CONCLUSION.

It is perfectly obvious that the production of high carbon ferro-chrome from chromite ore is quite easy at a low consumption of electrical energy. Apart from working out the minimum value for carbon content in the first stage, viz., reduction of the ore, the de-carbourisation of the high carbon ferro-chrome shall not look difficult. A low carbon alloy, if not totally carbon-free, can be produced from a high carbon one in an arc furnace of the Heroult type, quite easily, when worked on a large scale. Persistent work in the induction furnace, preferabl in a high frequency unit, shall give extra pure alloys if only worked on the proper scale. Also, from the figures given by workers abroad in the induction furnace, the cost of decarburisation is very cheap though the value of a low carbon alloy is disproportionately and unreasonably higher than a high carbon one. Correlating all these data about the working costs and economic rent on plant, site, etc., the problem of manufacture does not appear economically unsound. It may be solved with earnest effort, enterprise and proper financial help.

"Copy."

12-10-1933

GENERAL & REVENUE SECRETARIAT,

D. O. No. Rev B 1647
Ecol 15-33-2

Dated, Bangalore 11.10.1933

No.

Dear Mr. Balaji Rao,

Will you please let me have a full note as to the experiments about ferro-silicon and ferro-chrome that were undertaken by the Department some time ago, the results so far obtained and what further action is being taken. I should be obliged if you will kindly give your first attention to this as the matter is urgent.

Yours sincerely,

Your draft

B. Balaji Rao, Esq., B.A.,
Offg: Director of Geology
in Mysore, B a n g a l o r e.

fcol 15-33-3

GOVERNMENT OF MYSORE.

Telegraphic Address:—"GEOL."

MYSORE GEOLOGICAL DEPARTMENT,

No 7135-204
Enc: one file.

Bangalore, 13th October 193 3.

FROM

B.Balaji Rao, Esq., B.A.,

~~A.M.SEN, Esq., M.Sc., F.G.S.,~~

Offg. *Director of Geology in Mysore,*
Bangalore.

1361

GEN. & RBV. SECRETAT
14 OCT. 1933
DEVELOPMENT BRANC

DEVELOPMENT SEC.
14 OCT. 1933

TO

S.Abdul Wajid, Esq., B.A.,
Secretary to the Government of
His Highness the Maharaja of Mysore,
Development Department, Bangalore.

SIR,

With reference to your D.O. letter No.D.1647/Geol.15-33-2 dated 11th October 1933, I have the honour to submit herewith a brief note on the investigations carried on at Sivasamudram for the production of ferro-alloys in Mysore. Experiments for making ferro-chrome were first started in 1928-29 in the Central College, Bangalore, under the guidance of a Committee. After some time it was considered desirable to continue further experiments at Bhadravati. But owing to want of power and other reasons much progress was not made there. Further work was consequently discontinued and the transformers and other accessories connected therewith were all removed to Bangalore. About the end of January 1933 at the suggestion and encouragement of the then First Member of Council who was personally interesting himself in the progress of the experiments further investigations were started at Sivasamudram which had certain advantages such as continuous supply of electric power &c. over Bhadravati or Bangalore. The transformers and other equipments connected with the previous work were transferred from the Geological Department to Sivasamudram. After the furnaces were constructed and the transformers and other machinery were fitted up experiments were started under the direct supervision of Dr. Ram Prasad in consultation with Mr. Sen, Director of Geology. Mr. K.N.Srikanta Sastry, Research student who was working in the Geological Department in Ferro-chrome

experiments from the beginning and who was thrown out when the work was discontinued at Bhadravati, was temporarily entertained to help Dr. Ram Prasad at Sivasamudram. The raw materials required for the experiments such as the different grades of chromite , fireclay, charcoal, quartz &c. were all supplied by this Department and the funds required for the investigations were met by this Department out of the provision made in the departmental budget.

The furnaces were ready by the beginning of March and the first charges were made early in the month. After this it was decided to take up the investigations for the production of ferro-silicon as it was considered that this alloy was more important and was more in demand and the raw materials required were easily available. Since April last attention has been more or less devoted exclusively for the production of ferro-silicon. A number of charges were made every month commencing from April to end of September 1933, mixing the raw materials in different proportions to obtain a marketable product of the required specification but with varying results. The ferro-silicon produced varied in the percentage of silicon and iron in the samples obtained except in 3 or 4 which very nearly approached the required quality. Every endeavour is being made to get at it and from the analysis of some of the sample I am glad to say that they are found to contain higher percentage of silica with proper portion of iron. Besides Dr. Ram Prasad is of opinion that the various factors in the experiments have been standardised and kept constant. By slight modification in the design of the furnace he says it was possible to draw out the molten metal at the bottom. The experiments conducted so far have been fairly successful. The samples of ferro-alloys obtained from each charge have all been analysed in the Geological Laboratory except a few which were analysed at Bhadravati as the necessary apparatus for the determination of carbon was not available with us.

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The bigger transformers have been received and it is proposed to construct larger furnaces and to start the work on a larger scale.

Total amount spent on these experiments from February 1933 up to date including the salary of the Ferro-chrome Assistant is Rs.889-9-0

Dr. Ram Prasad has been requested to send his report on the experiments now conducted at Sivasamudram and what further action is considered necessary for continuing the experiments. His report when received will be submitted to Government.

I herewith enclose a short note re: the ferro-chrome and ferro-silicon experiments conducted from the beginning and also copies of Dr. R.K.Ram Prasad's two reports for the information of Government.

I have the honour to be,

Sir,

Your most obedient servant,

Offg. Director,

Mysore Geological Department.

Bs.13/x

FERRO-CHROME EXPERIMENTS

During 1929-30 (culled from the Administration Report for that year)

The preliminary experiments conducted during the year 1928-29 in an arc furnace by employing direct current having proved fairly successful in the production of ferro-chrome it was resolved to conduct further experiments with alternating current, there being economy in plant and in power consumption. The transformers and reactors necessary for this purpose were installed in the Central College premises. After some work under varied conditions it was found possible to obtain samples of alloy fairly homogeneous in constitution as well as in composition. Experiments were also conducted with varied porportions of the ingredients constituting the charge in cases of different grades of the ore so as to find utility for all grades of the raw material available in the State.

As the market value of ferro-chrome is largely based on the percentage impurity of carbon in the alloy combustions were conducted to estimate the same. As the figure in some cases was as high as 7 to 8 per cent steps were taken to reduce in a single operation the amount of carbon to as low a figure as possible without high losses of chromium in the slag.

Methods for the decarbonisation of ferro-chrome were also investigated at the Indian Institute of Science.

As, industrially, the three phase power has to be employed experiments will be conducted in a three phase furnace after the arrival and installation of the fresh transformers, etc. ordered for.

FERRO-CHROME EXPERIMENTS.

For the year 1930-31 (culled from the Administration Report)

Experiments were carried on in continuation of work conducted in 1929-30 in the single phase arc furnace with alternating current. Considerable improvement was effected in these experiments as a result of which ferro-chrome of a satisfactory quality was obtained.

Two experiments were conducted in September 1930 on the production of high carbon ferro-chrome from chromite ore in the 270 k.v.a. Heroult ½ ton steel furnace at Bhadravati. The energy consumption to get a 6 per cent carbon ferro-chrome was as low as 4.8 units per pound. The attendant troubles, too frequent and quite common on a small scale work, were found to be totally absent in the large furnace. But as the roof of the furnace was badly damaged, further work was stopped.

On receipt of two new transformers, a three-phase arc furnace was built up and the required electrical plant and controlling gear were installed at the same place in the Central College, Bangalore. Work in this furnace proved more promising than in the single phase plant. A number of experiments both on the smelting of chromite ore and the decarburisation of the high carbon ferrochrome were tried in this furnace and it was found possible to decarburise the alloy from about 9 per cent carbon content to 4 per cent generally and sometimes to under 3 per cent.

Some attempts on decarburisation were made also in the k.w. high frequency induction furnace at the Indian Institute of Science, and the results were found to be highly encouraging for conducting further experiments.

It has been decided that some more experiments may be conducted in the 3 phase Heroult furnace at Bhadravati, so

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so that a large charge might be dealt with at a time. This would help to obtain some more useful information, specially as regards the cost of the smelting process, when worked on a fairly large scale.

For the year 1931-32 (culled from the Administration Report)

It was stated in the last year's report that a number of experiments both on the smelting of chromite ore and the decarburisation of the high carbon ferro-chrome were tried in the three-phase arc furnace built up in the Central College, Bangalore; and it was found possible to decarburise the alloy from about 9 per cent carbon content to 4 per cent generally and sometimes to under 3 per cent.

These experiments were stopped during the year under the advice of the Special Committee; and further experiments were ordered to be conducted at Bhadravati by using the three-phase Heroult half ton furnace to deal with a larger charge at a time.

Though it was found that the electric power obtained from the new turbo-generator fixed up at Bhadravati would be quite sufficient for the production of ferro-chrome in the Heroult furnace, the latter was, however, declared to be quite unsuited for the manufacture of ferro-alloys on account of the troubles to its roof and sides. Owing to the production of a large amount of gas and the longer period of heating required for the reduction of the ore, the roof of the furnace would not stand more than two to three charges after which the roof and probably the sides would have to be relined or patched up as found necessary.

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For these reasons, the idea of conducting further experiments in this furnace was altogether dropped for the present and the Ferro-chhome Assistant was kept engaged with the production of steel in another Electrical furnace (Hoskins) at Bhadravati. At the end of the year, his services were dispensed with.

Ferro-alloy Experiments.

1932-33 (culled from the Administration Report)

As stated in the last year's report, these experiments were stopped in the three phase arc furnace built up in the Central College, Bangalore; and attempt was made to work the Heroult furnace at Bhadravati for this purpose. For reasons already stated in that report the idea of conducting further experiments at Bhadravati was also abandoned.

As it was considered by Government desirable to continue these experiments at Sivasamudram where the continuous supply of electric power could be relied upon, the Chief Electrical Engineer was consulted in the matter; and he agreed to have these experiments conducted at Sivasamudram under the supervision of Dr. Ram Prasad. Accordingly Government were pleased to order in March 1933 the resumption of this work at Sivasamudram to be carried on under the supervision of Dr. Ram Prasad with the help of an operator. Mr. K.N.Srikanta Sastry, B.Sc., whose services as Ferro-chrome Assistant were dispensed with in June 1932, was re-entertained in February 1933 on a temporary basis for this purpose. All the electrical appliances with accessories previously obtained in connection with these experiments were transferred to Sivsamudram from this department.

The electric furnace was got ready by the first week of April 1933 and four experiments were made for the production of ferro-chrome from Byrapur high grade Chromite

ore. At this stage it was considered desirable by Government to produce ferro-silicon of requisite specification which would get a market in the iron and steel works of India. As this alloy can be made in the furnace meant for the production of ferro-chrome, the experiments in connection with ferro-silicon were started under instructions of Government with the Mysore raw materials and those for ferro-chrome would be taken up later.

Up to 30th June 1933, altogether 35 experiments have been conducted for ferro-silicon, and three for carborundum; but in no case the standard specification of 75% silicon and 21% iron was obtained, though in a few cases the silicon content only was approximately approached a little higher or lower than the required percentage, whereas the iron content has yet to be regulated in the same alloy.

As the alloy was not successfully tapped out of the furnace in a fluid condition, the product obtained was generally coated on the surface with impurities like carbon and fused quartz and occasionally with a few small crystals of carborundum

When a larger furnace is constructed having a regular arrangement for tapping the fluid alloy with higher capacity transformers, it is expected the results would soon come up to the required specification, after further experiments are conducted.

All the samples of ferro-alloys produced at Sivasamudram are analysed in the Chemical Laboratory of this Department.

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Dated 9-6-1933

Dr. Ram Prasad's report on the Ferro-silicon experiments conducted at Sivasamudram.

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Experiments conducted at Sivasamudram appear to be very encouraging. A larger furnace is likely to be built in conjunction with 3 Transformers of 75 KVA. each and the results in the new furnace continously operated, are awaited with much interest.

Quartz used at Sivasamudram appears to be exceptionally pure, although even lower grades containing about 95- 96 % SiO_2 are extensively used in the commercial production of FeSi. In one of our trials at Bhadravati our raw materials, was to start with, old silica brick, which was later changed to quartz, analysing about 96% SiO_2. Selection of suitable quartz is merely a question of cost, provided it contains at least 95% SiO_2. There seems to be no need to insist on a very much purer stuff.

For reducing agents, coke, charocal or anthracite may be used although for higher grades, containing upwards of 75% Si. Charcoal is invariably used in view of its lower ash content and comparative freedom from impurities. The cheapest available carbonaceous material, free from injurious elements like P and As, may be used. In our case charcoal being the cheapest stuff will do admirably. We tried coke at first which was later changed to charcoal. So far as the operation was concerned there was not much difference. It may be necessary to throw a few pieces of coke or old electrode pieces round about the electrodes at the commencement of operation.

Regarding the furnace lining, we had no difficulty, since we had sufficient pieces of old electrodes and carbon plates, which were powdered, mixed with tar and rammed. The walls of the furnace need occasional repairs while the bottom lasts for a fairly long period.

About the difficulty in tapping, I think the trouble is due to the arc playing too much on the surface. It is very necessary that the arcs should be buried deep enough in the furnace and plenty of fresh charge put on the top. This not only keeps the Fe Si. fluid, but prevents the loss of Si. by volatilisation, which otherwise becomes excessive. We had the same difficulty in the first two experiments; but in later experiments, the furnace was tapped thrice in a 4 hour period, and the Fe.Si. flowed freely into the receptacle placed underneath. When the furnace was cleaned after it became cold, there was practically no metallic stuff at the bottom.

Power consumption is naturally high in all small scale trials. The best figure we had was about 22 KWH. per lb. of 50% grade. There is no need to be alarmed at this high figure so long as we operate a small furnace. In a 4000 KVA. Ferrosilicon furnace in Sweden, which I visited recently, they were using 9000 KWH. per ton of 75%. FeSi. which works out to about 4 KWH. per lb. A 50% alloy would consume about 7000 KWH. per ton.

Carbon content in ferrosilicon gradually diminished as Si. containing 50% Si. and upwards is sually round about .2 - .4% may be even less. This is not because any special care is taken in the manufacture of these grades to remove C. but when Fe and Si. unite together, iron has no affinity for carbon. Determination of C in FeSi. is therefore of minor importance.

The appearance of a little carborundum mixed up with ferro-silicon is probably due to the fact that the FeSi. could not blow out of the furnace, in which case it would be pure ferrosilicon free from all other impurities. In a well operated Ferrosilicon furnace there is not much for the formation of any appreciable quantity of carborundum, specially of the crystalline variety. The latter stuff is made in specail electric resistance furnaces, as a temperature of about 1850^{o} C. and dissociated 2220^{o} C to 2240^{o} C.

No mention is made in the report about the kind of electrode used and its consumption. I expect graphite electrode was used. As the consumption of electrode is a major item in the cost of production, it has to be investigated whether Soderburg continuous electrodes made with local materials, cannot be successfully used.

REPORT ON FERRO-SILICON EXPERIMENTS

dated 25-5-1933 by Dr. B. K. Rama Prasad.

The experiments on Ferro-silicon were started on 7-4-33 and 14 samples have been prepared up-to-date. The Chief Electrical Engineer personally inspected the working during his visits to Sivasamudram and the Director of Geology also witnessed two sets of experiments during his visit on the 19th and 20th instants to Sivasamudram.

Although 14 samples are made, more than 20 experiments were conducted, in some of which we obtained carborundum as a by-product. A few investigations had to be made to eliminate this and we have now succeeded in producing Ferro-silicon of any required grade without the contamination of carborundum. Incidentally a few experiments were also conducted to produce pure carborundum, which is a very useful abrasive and can be used for making "Emery" paper and grinding wheels and blocks required for the Workshops and for cleaning machinery, etc. A separate report will follow about this.

The first five experiments on Ferro-silicon were made using ordinary quartz containing 98.77% silica that was picked up locally. The percentage of silicon in the product was gradually increased as shown in the statement below. Experiments 6 and the following were conducted using the pure quartz sent by the Director of Geology (containing 99.28% silica) and it was found that the process was much smoother in operation. For reducing agents, coal, coke and charcoal were used to determine the most suitable material and also the quantities required. The Director of Geology is arranging to send some Lantana charcoal also for investigation. Steel scrap picked up from our Workshop is being used and found satisfactory. Charcoal, coke and Tar are being used for the Furnace lining, taking care that the bottom of the Furnace is fairly conducting to enable the smooth working of the Furnace.

The Bank of 45 K.W. Transformers sent by the Geological

Department is used for power and 55-volts is being adopted as it is found quite satisfactory.

Attempts were made to tap the furnace, but the heat of the small furnace is not found enough to keep the alloy in a fluid condition when it is tapped. Some more modifications are being attempted to accomplish this, pending the construction of a bigger furnace, when the required Transformers are received and installed.

Expt. No.	Charge of Raw materials. Quartz.	Steel.	Coke Coal	Charcoal.	Qnty. used.	Qnty. yield	Analysis Si	Fe	Remarks.
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.			From 7-4-33
1.	10	10	2¼	3½	5	1/4	18.8	79	using ordi-
2.	10	10	6	-	1½	3/8	11	87	nary Quartz
3.	10	10	6	-	14½	2¾	20	80	containing
4.	26	4	9	1	5	3/4	46	52	98.77 silic
5.	26	4	9	1	15	1¾	53.5	36	to 18-4-33.
6.	13	4	-	7½	24	5½	43.7	55.6	From using high grade quartz received from Porcelain Fat.
7.	18	2	1½	9½	21	3/4	53.5	44.5	
8.	9	1	-	5½	15	4	66	30	
9.	9	5/8	-	5½	15	1¼	expected)		
10.	9	5/8	-	5½	15	1¾	"		99.28 silic graphite bottom furnace.
11.	10	5/8	-	6	16	2 1/8	"		-do- charcoal bottom for furnace.
12.	8½	1	4½ coal	-	14	1 1/8	"		
13.	10	5/8	-	6	16	2½	"		
14.	5	1/4	-	3	8	2	"		Furnace lining at bottom was fixed with coke & tar. to 21-5-33

The percentage of silicon in samples 12, 13 and 14 is expected to be nearly 75% and will be intimated when analysis is received from Director of Geology. The furnace lining was

gradually modified in order to make it as cheap as possible and finally for the side lining charcoal and tar mixture was adopted. For the bottom of the Furnace charcoal was found unsuitable, as its conductivity was low and it tends to help the production of carborundum as a bye-product. Coke and tar was finally adopted, as it gives the best results and does not form carborundum.

The consumption of Electric energy per lb. of Ferro-silicon produced is very high in all these experiments ranging from 20 units per lb. in the earlier experiments to 15 units in the later ones. This is partly becuase the Furnace is of very small capacity and is run intermittently and much of the heat is lost. According to the published literature on the subject, the consumption of power is stated to be about 5 to 6 units per lb. of Ferro-silicon of 50% grade on very large scale production. For 75% grade this may work up to 7 to 8 units per lb. In a small Furnace of 200 K.W. capacity, the figures will be higher, say about 10 units per lb. and we will be in a position to check this when our Transformers are received and a bigger furnace is constructed.

The comparative cost in 1916 of 50% Ferro-silicon in various countries was as follows:-

Norway	₰46 per ton	(2240 lbs)
France.	₰50 " "	
United States.	₰60 " "	

The rate at which the Tata Iron and Steel Company are purchasing 75% Ferro-silicon containing less than ½% carbon is £21 per ton C.I.F. Calcutta.

Out of ₰46, the cost in Norway, the power cost is ₰6.6

" ₰50 " " France " " ₰15.0

" ₰60 " " U.S.A. " " ₰21.0

We will be able to figure out similar proportion costs after we produce the alloy on a larger scale.

GOVERNMENT OF MYSORE

fcf 15-33-4

Telegraphic Address:—"GEOL

MYSORE GEOLOGICAL DEPARTMENT,

No. 7135-206

Bangalore, 16th October 1933.

FROM B. Balaji Rao, Esq., B.A.,

Offg. *Director of Geology in Mysore*,
Bangalore

GEN. & RE., SECRETARIAT, OCT 1933, DEVELOPMENT BRANCH.

16 OCT

To S. Abdul Wajid, Esq., B.A.,
Secretary to the Government of
His Highness the Maharaja of Mysore,
Development Department,
B a n g a l o r e.

SIR,

In continuation of my letter No.7135-204 dated 13th October 1933, I have the honour to forward herewith the report of Dr. B.K. Ram Prasad on the investigations for the manufacture of Ferro-chrome and Ferro-silicon at Sivasamudram.

have the honour to be,

Sir,

Your most obedient servant,

Offg. D i r e c t o r,
Mysore Geological Deptt.

Bs.16/x

MANUFACTURE OF FERRO-CHROME AND FERRO-SILICON.

During the year 1930 and 1931 a number of experiments were conducted in the Central College, Bangalore, under the direction of the Ferro-chrome Committee to reduce high grade and low grade chromite ores that were being mined by the Geological Department. The results obtained were encouraging and the analysis of the representative samples showed 55% chromium, 25% Iron, 5 to 6% Carbon silicon and other elements 15%. Two large scale experiments were conducted in the Heroult Furnace at Bhadravati and nearly half a ton of alloy was produced.

2. Further work on the manufacture of Ferro-chrome was resumed at Sivasamudram in February 1933 using the small Transformers and equipment that were employed in the year 1931 under the direction of the Chief Electrical Engineer, the Director of Geology and the personal supervision of Dr. Ram Prasad, the Superintendent of Electrical Works. The Assistant who was working on these experiments was again deputed to, ~~actually~~ work with the Furnace.

Four experiments were conducted on Ferro-chrome in March and early in April 1933, and the alloy analysed as Cr.% 55.97 Fe. 37.82%.

3. During the second week of March 1933, instructions were received that experiments on the production of Ferro-silicon may be taken up, as there was a fairly good demand for this alloy in India. Early in April a small quantity of Quartz was obtained locally and Ferro-silicon was produced using charcoal as reducing agent, and steel turnings from the Workshop as the iron for the alloy. Later on the best quality Peenya Quartz (99.28% silica) was used and about 60 samples were made using different proportions. During the later experiments, the ferro-silicon alloy was tapped out of the Furnace in a pure condition.

The different standard alloys produced keeping the required quantity of silicon and iron are as follows:-

I.	Si. 20%,	--	Fe. 79.8%
II.	Si. 44%,	--	Fe. 55.6%
III.	Si. 54%,	--	Fe. 44.5%
IV.	Si. 66%,	--	Fe. 32.5%
V.	Si. 71%,	--	Fe. 28.9%
VI.	Si. 76.1%	--	Fe. 23%
VII.	Si. 85%	--	Fe. 13%

4. There is a market in India for the high percent silicon alloy and The Tata Iron and Steel Co., consume about 80 tons of Ferro-chrome per year and 700 tons of Ferro-silicon There are a few small steel foundries such as the Hukumchand Steel Works, who also consume appreciable quantities of Ferro-silicon. The Tata Iron and Steel Company use the alloy containing 75% Si. and about 21% Fe. In our experiments this type of alloy was produced satisfactorily and the metal was tapped out.

5. In order to obtain proper data regarding the cost of energy and the cost of raw materials, it is necessary to carry out the experiments on a larger scale using a Furnace of a capacity of about 200 K.W. The Chief Electrical Engineer has kindly provided us with the necessary Electrical apparatus and experiments on a larger scale are expected to be started from November 1933.

6. During the time of the construction of the bigger furnace, some further experiments on Ferro-chrome are being conducted and about 21 samples have been prepared since September 1933. The analysis of the best tapped samples show about 59% chromium and 33% Fe, which compares favourably with the standard samples of Ferro-chrome of this grade.

W5

7. As the carbon content of Ferro-chrome is to be determined and as the chemical laboratory of the Geological Department is not yet equipped with carbon determination apparatus, it may be advisable to send the representative samples to Bhadravati and get the analysis.

Large scale experiments on Ferro-chrome also will be conducted hereafter. The effect of various types of reducing agents such as Coal, Charcoal, Lantana Charcoal,etc., are being investigated.

8. The approximate cost of Ferro-chrome and Ferro-silicon in the market is as follows:-

Ferro-chrome of 60% Cr., 6% carbon. } about Rs.400/- per ton.

Ferro-silicon of 75% Si. -- about Rs.300/- per ton.

Ferro chrome Contg: less than 1% Carbon about Rs 1500 per ton

======:o(0)o:======

R Prasad 14/10/33

Superintendent of Elec:Works,
C.P.S. Sivasamudram.

==========

RP-DMJ.
14-10-33.

MMS.
16.10.33.

Appendix F G—1]

SUBJECT .....

.....

.....

Section Genl

File No. 15-33

Serial No. 5

Diary No. of letter replied to .....

No. 10 01753

To

~~The Secretary~~

Mr Balaya Rao

Dear Sir

General and Revenue Secretariat

( )

the *193*

with reg. to your letter

no 7135-104 dated 13/10/33,

I am desired to request you to

kindly forward a detailed report

& date

on the results & recall of the

work done Zero-chrome experiments

conducted at Bhadravati &

also to enquire why it was decided

to discontinue it at the

end of July 1932

Date of issue 21/10/33

Signed by K Sec. Secretary

This may be kindly treated as very urgent

By S.

List of enclosures .....

21/10.

Copied by .....

To I B Balaya Rao by B.A.

Mysore Iron & Steel.

Examined by .....

GENERAL AND REVENUE SECRETARIA

D. O. No. D 1753

Gen 15-33-5

Dated, Bangalore, 21st October 1933.

Dear Mr. Balaji Rao,

With reference to your letter No.7135-204 dated the 13th October 1933, I am desired to request you to kindly forward a detailed report showing the nature and result of the Ferro-chrome experiments conducted at Bhadravati and also to enquire why it was decided to discontinue it at the end of July 1932.

This may be kindly treated as very urgent.

Yours sincerely,

To

Mr B. Balaji Rao

Mg Dy Secy

GOVERNMENT OF MYSORE. Geol. 15-33-6

MYSORE GEOLOGICAL DEPARTMENT.

Telegraphic Address:—"GEOL."

No. 7135-212
C 3

Bangalore, 24th October 193 3.

1487

GEN. & REV. SECRETARIAT. 5 OCT. 1933 DEVELOPMENT BRANCH.

DEVELOPMENT SECRETARIAT. 24. OCT. 1933

FROM

B. Balaji Rao, Esq., B.A.,
Offg. *Director of Geology in Mysore,*
Bangalore.

To

S. Abdul Wajid, Esq., B.A.,
Secretary to the Government of
His Highness the Maharaja of Mysore,
Development Department,
B a n g a l o r e.

SIR,

With reference to your D.O. No.D.1753/Geol.15-33-5 dated 21st October 1933 I have the honour to submit herewith a further note on the investigations carried on for the production of ferro alloys in Mysore.

The Committee appointed by Government to conduct experiments for the manufacture of Ferro-chrome made a number of small experiments for the reduction of the carbon contents in the Central College during 1929-30-31. It was then decided to carry on experiments on a large scale with the Heroult furnace at Bhadravati. This was done and the first ferro-chrome ingots were produced which carried Fe 46.18%, Cr 46.22% and 6.35% carbon (specimen No.7.515). Afterwards experiments were conducted in the Central College to decarburise the ferro-chrome and it was fairly successful since it was possible to reduce the percentage of carbon from 6 to 4%.

The Committee then advised ~~that~~ the experiments to be conducted at Bhadravati on a large scale to further decarburise the ferro-chrome. While this was under consideration, under the pressure of the University authorities who wanted the chemical block free on account of the advent of the Science Congress, the small scale experimental plant was dismantled and the ferro-chrome assistant was transferred to Bhadravati to conduct large scale experiments in the Heroult furnace in July 1931.

After some time it was found that the Heroult's furnace was not quite suited for ferro-chrome experiments on account of certain defects: partly (i) due to roof and sides of the furnace not standing the excessive heat required for the reduction of the ore as the lining was giving way and it was necessary to reline them frequently after two or three changes, but mainly (2) it was not possible to supply the needed electric power from the newly installed Turbo-generators to the ferro-chrome furnace to conduct large scale experiments. For these reasons the experiments had ~~therefore~~ to be stopped and the ferro-chrome assistant was kept engaged there for the rest of the period in conducting certain experiments in the production of steel in another electric furnace (Hoskin's). Monthly summaries of his report are herein enclosed for the information of Government.

The service of the Ferro-chrome assistant was dispensed with from July 1932. But when it was ~~pointed out by the~~ considered by Mr. ~~Inspector~~ that it was desirable and necessary also in the interests of ferro-chrome industry to conduct more experiments, it was decided to proceed to Sivasamudram where power was readily available. Accordingly the Ferro-chrome Assistant was re-employed on 17th February 1933 and not only ferro-chrome but ferro-silicon experiments are being taken on hand.

The report on the experiments now conducted at Sivasamudram has been forwarded to Government with this office letter No. 7135-206 dated 16th October 1933.

I have the honour to be,

Sir,

Your most obedient servant,

Offg. Director,

Mysore Geological Department.

Bs.24/x

Work Report for April 1932.

of Mr. K.N.Sreekanta Sastry, Ferro-chrome Asst.

The work for the month was mainly in the Hoskin's furnace. Only one special cast iron melt was made in the Heroult furnace in the usual manner to cast chilled wheels required for tramways. In the Hoskin's furnace, six heats of crucible steel were made from steel scrap as usual and the melt cast into gun-shells, spanners, pinion wheels, bevel gears and eccentric straps. Also the heats of semi-steel were made and poured into bushings required to make small sized piston rings. Twentysix heats of brass melting were made for the purposes of the General Foundry.

'Copy'.

24.10.33.

Work Report for March 1932.

of Mr. K.N.Sreekanta Sastry, Ferro-chrome Asst.

The work during this month was mainly conducted in the Hoskin's Electric furnace, only three white iron heats for the chilled castings for tramway wheels being done in the Heroult furnace. One steel heat was made in the Heroult furnace during my absence on leave.

It was found from previous experience that steel will chill quick enough before we complete pouring small moulds, many in number, from a large ladle full of metal. A crucible heat of steel was therefore considered more desirable in obtaining small sized castings. The Hoskin's furnace was therefore brought into service, wherein a crucible filled with steel scrap-howsoever irregular in shape - was put in the furnace chamber and the furnace switched on. As the metal sunk down after melting, fresh scrap was added, gently and gradually to the molten metal. After the whole volume attained the desired temperature small quantities of Ferro-alloys and Aluminium were added and the metal well stirred. A few minutes later the metal was cast. Nine steel heats were conducted and several models like hand hammers, tramway pivot bearing, plummer block and gun shells were tried. Also, a heat of semi-steel was made to cast Tramway loco piston rings by using steel scrap and pig iron.

Besides, the Hoskin's furnace was also operated for the service of the General foundry to melt their brass and copper. Fourteen brass heats, two copper melts and one white metal melt were conducted.

Copy
14.10.32

Work Report for February 1932.

of Mr. K.N.Sreekanta Sastry, Ferro-chrome Asst.

Six steel castings and two special iron castings for the General Foundry were made in the course of this month. Test bars, in a few cases, were made to know the mechanical qualitites of the samples cast and tested in the laboratory for tension. It is proposed to conduct other tests also in future on all samples.

The special iron castings were made by using only ordinary cast iron borings (10 cwts. in each case) which otherwise should have been thrown out as waste material and no pig iron was used. The addition of steel scrap to cast or pig iron was suspended. The test results were, however, not highly encouraging for the special quality desired. Proposals to vary composition to secure better material are under contemplation.

1000 lbs. of steel turnings only were used in each case as raw scrap for the process and the irregularly shaped miscellaneous scrap that entails longer duration for melting was avoided. Various models like the anvil, hammers, sprocket wheel and taggle plates were cast. Several defects like blow-holes, surface blisters and chilling of metal were noticed, specially when the steel was low in carbon content. Attempts are being made to avoid them by rectifying our process of steel founding which, in its essentials, differs greatly from the small quantities of chromium into cast steel, are of late, being made. The test results are fairly satisfactory.

Also, the Hoskins' Furnace was rigged up, the electrical and cooling water connections repaired and the furnace restored to running condition to anneal small size steel castings.

'Copy'
24.10.33

G.R.S. III—3]

Routine Notes.

[To be used only for notes, requisitions, etc., not intended for permanent record.]

57

Dear Mr Venkateswaran

Thanks much
for copies of notes
& reports about the
experiments re ferro-
chromes ferro-nickel-
manganese. I am glad you
will [illegible] have papers
ready by [illegible]
Remove as this
interferes & let me have
your suggestions as to
further [illegible]
experiments for disp-

N.B.—Should routine notes be written on small slips, the notes must be copied, or slips pasted on this form.

App. F. XI-3] REGISTER OF "SUSPEND C" CASES OF THE..... ....BRANCH.

WD 0552—GPB—36,000—7-12-25

Register No.	Date of receipt	File and Serial No.	Brief Subject of the file	Reason why in is included in this list	Remarks
1	2	3	4	5	6

Dear Mr. Venkatesachar,

I herewith send you copies of note and reports about the experiments re ferro chrome and ferro-silicon. I shall be glad if you will go through these papers, show them to Sir C.V. Raman and any other - - - Scientists and let me have your suggestion as to the further conduct of these experiments.

Yours sincerely,
Sd/ K.Matthan.

Issued on 7/11/33

UNIVERSITY OF MYSORE.

DEPARTMENT OF PHYSICS.

CENTRAL COLLEGE,
BANGALORE (S. INDIA.)

DEVELOPMENT SECTION
Ref. No. .....
10. NOV. 1933

Date 9th November 1933

GEN. & REV. SECRETARIAT.
11 NOV 33
DEVELOPMENT BRANCH.

1745

Dear Mr. Matthan,

I am in receipt of copies of notes and reports on experiments concerning Ferro-Chrome and Ferro-Silicon. After going through them shall write to you what I think should be done in this Connection. I mean paying a visit to Sivasamudram along with Sir Venkataraman, to get a first hand idea of the progress so far made.

Yours Sincerely
B. Venkatesachar

Raja mantra pravina,
Diwan Bahadur,
K. Matthan, B.A.
Member of Council

University of Mysore

RAO BAHADUR
B. VENKATESACHAR, M.A.
PROFESSOR OF PHYSICS

DEPARTMENT OF PHYSICS
CENTRAL COLLEGE
BANGALORE

25th November 1933

Dear Mr: Matthan,

I had a talk yesterday with Sir Venkata Raman in connection with the the subject of Ferro-chrome and Ferro-Silicon. After making a preliminary survey of all the available literature on the subject we shall be soon visiting Sivasamudram as mentioned in my last letter to you. Sir Venkata Raman has promised to bestow his best attention to the subject.

With best regards,

I am
Yours sincerely,

B. Venkatesachar

Rajamantrapravian Diwan Bahadur
K. Matthan, Esq., B.A.,
Member of Council,

GOVERNMENT OF MYSORE.

Telegraphic Address :—"GEOL."

In all communications please quote our reference
No. G. 1891

MYSORE GEOLOGICAL DEPARTMENT

Bangalore, 6th April 1940.

FROM

B. RAMA RAO, ESQ., M.A., D.I.C., F.G.S.,
Director of Geology in Mysore,
Bangalore.

To

CHARLES E. NORONHA, ESQ., M.A.,
Secretary to the Government of
His Highness the Maharaja of Mysore,
Development Department, Bangalore.

SIR,

With reference to your letter No.AF.5036/Geol. 15-33 dated 25th March 1940 requesting to send report regarding investigation on the possibility of manufacturing lower grades of ferro-chrome, I have the honour to state that, since there are no adequate facilities in this Department, to conduct those experiments and as one of the Chemists has been continuously on long leave, it has not been possible to make any arrangements to conduct the experiments. I beg to suggest that these experiments could be conducted with advantage at Bhadravati

P.T.O.

Bhadravati by the Mysore Iron and Steel Works who, perhaps, have all the required facilities. The Department will be glad to supply the raw materials required.

I have the honour to be,
S i r ,
Your most obedient servant,

BRamaRao

D I R E C T O R ,
Mysore Geological Department.

Ar.6/4

Appendix F G—1]

SUBJECT... .....

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.....

Section Geol

File No. 15-33

Serial No.

No. A76585/ME

Diary No. of letter replied to.. .....

To

The Chairman
Mysore Iron & Steel Works
Bhadravati

General and Revenue Secretariat

( )

the *193*

Date of issue 27-5-40

Signed by ..... Mr H N Rao

Sir,

With reference to the correspondence ending with your U.O. No. B.636 d. 8.5.40 re: the manufacture of ferro-chrome I am directed to forward herewith for your information a copy of extract from the letter d. 24.4.40. from Dr. E.P. Metcalfe and to the Dewan.

I have etc

H.S.O. 23/5/40.

For Devl. Secy

List of enclosures.... ....

Copied by. .....

Examined by .. ..

KM
22/5/40